

WHAT IS CLAIMED IS:

1. An etching process for removing silicon from the surface of a silicon wafer, the process comprising contacting the surface of the silicon wafer with a caustic etchant in the form of an aqueous solution comprising water and a source of hydroxide ions, the concentration of water in the caustic etchant being less than 45% by weight.

2. The etching process of claim 1 wherein the concentration of water in the caustic etchant is at least about 10% by weight.

3. The etching process of claim 1 wherein the concentration of water in the caustic etchant is at least about 20% by weight.

4. The etching process of claim 1 wherein the concentration of water in the caustic etchant is at least about 25% by weight.

5. The etching process of claim 4 wherein the concentration of water in the caustic etchant is from about 30% to about 42% by weight.

6. The etching process of claim 5 wherein the concentration of water in the caustic etchant is from about 30% to about 37% by weight.

7. The etching process of claim 1 wherein the concentration of the source of hydroxide ions in the caustic etchant is greater than 55% by weight.

8. The etching process of claim 7 wherein the concentration of the source of hydroxide ions in the caustic etchant is at least about 58% by weight.

9. The etching process of claim 7 wherein the concentration of the source of hydroxide ions in the caustic etchant is at least about 60% by weight.

10. The etching process of claim 7 wherein the concentration of the source of hydroxide ions in the caustic etchant is at least about 62% by weight.

11. The etching process of claim 7 wherein the concentration of the source of hydroxide ions in the caustic etchant is at least about 65% by weight.

12. The etching process of claim 7 wherein the concentration of the source of hydroxide ions in the caustic etchant is no more than about 75% by weight.

13. The etching process of claim 12 wherein the concentration of the source of hydroxide ions in the caustic etchant is from about 58% to about 70% by weight.

14. The etching process of claim 13 wherein the concentration of the source of hydroxide ions in the caustic etchant is from about 58% to about 65% by weight.

15. The etching process of claim 14 wherein the concentration of the source of hydroxide ions in the caustic etchant is from about 62% to about 65% by weight.

16. The etching process of claim 7 wherein the source of hydroxide ions comprises an alkali metal hydroxide selected from the group consisting of sodium hydroxide and potassium hydroxide.

17. The etching process of claim 1 wherein the caustic etchant further comprises a salt additive.

18. The etching process of claim 17 wherein the salt additive is selected from the group consisting of inorganic alkali and alkaline earth metal salts and mixtures thereof.

19. The etching process of claim 18 wherein the salt additive comprises a compound selected from the group consisting of potassium fluoride and potassium carbonate.

20. The etching process of claim 18 wherein the concentration of the salt additive in the caustic etchant is no more than about 25% by weight.

21. The etching process of claim 20 wherein the concentration of the salt additive in the caustic etchant is from about 5% to about 25% by weight.

22. The etching process of claim 18 wherein the concentration of the source of hydroxide ions in the caustic etchant is greater than 55% by weight.

23. The etching process of claim 1 wherein the temperature of the caustic etchant contacted with the silicon wafer is at least about 70°C.

24. The etching process of claim 23 wherein the temperature of the caustic etchant contacted with the silicon wafer is from about 70°C to about 120°C.

25. The etching process of claim 24 wherein the temperature of the caustic etchant contacted with the silicon wafer is from about 75°C to about 85°C.

26. The etching process of claim 1 wherein the surface of the wafer is contacted with the caustic etchant by immersing the wafer in the caustic etchant.

27. The etching process of claim 26 wherein the wafer is rotated while immersed in the caustic etchant.

28. The etching process of claim 27 wherein the rate of rotation of the wafer immersed in the caustic etchant is from about 1 revolution per minute to about 100 revolutions per minute.

29. The etching process of claim 26 wherein the wafer is immersed in the caustic etchant for a time such that the amount of silicon removed from the surface of the wafer is from about 10 μm to about 30 μm in terms of total thickness from both the front and back surface of the wafer.

30. The etching process of claim 1 wherein the surface of the wafer is contacted with the caustic etchant by spraying the surface of the wafer with the caustic etchant.

31. The etching process of claim 30 wherein the wafer is rotated while the surface of the wafer is sprayed with the caustic etchant.

32. The etching process of claim 31 wherein the rate of rotation of the wafer is from about 50 revolutions per minute to about 650 revolutions per minute.

33. An etching process for removing silicon from the surface of a silicon wafer, the process comprising contacting the surface of the silicon wafer with a caustic etchant in the form of an aqueous solution comprising water and a source of hydroxide ions, the concentration of the source of hydroxide ions in the caustic etchant being greater than 55% by weight.

34. The etching process of claim 33 wherein the concentration of the source of hydroxide ions in the caustic etchant is at least about 58% by weight.

35. The etching process of claim 33 wherein the concentration of the source of hydroxide ions in the caustic etchant is at least about 60% by weight.

36. The etching process of claim 33 wherein the concentration of the source of hydroxide ions in the caustic etchant is at least about 62% by weight.

37. The etching process of claim 33 wherein the concentration of the source of hydroxide ions in the caustic etchant is at least about 65% by weight.

38. The etching process of claim 33 wherein the concentration of the source of hydroxide ions in the caustic etchant is no more than about 75% by weight.

39. The etching process of claim 38 wherein the concentration of the source of hydroxide ions in the caustic etchant is from about 58% to about 70% by weight.

40. The etching process of claim 39 wherein the concentration of the source of hydroxide ions in the caustic etchant is from about 58% to about 65% by weight.

41. The etching process of claim 40 wherein the concentration of the source of hydroxide ions in the caustic etchant is from about 62% to about 65% by weight.

42. The etching process of claim 33 wherein the source of hydroxide ions comprises an alkali metal hydroxide selected from the group consisting of sodium hydroxide and potassium hydroxide.

43. The etching process of claim 42 wherein the source of hydroxide ions comprises sodium hydroxide.

44. The etching process of claim 43 wherein the concentration of sodium hydroxide in the caustic etchant is at least about 58% by weight.

45. The etching process of claim 43 wherein the concentration of sodium hydroxide in the caustic etchant is at least about 62% by weight.

46. The etching process of claim 43 wherein the concentration of sodium hydroxide in the caustic etchant is no more than about 68% by weight.

47. The etching process of claim 46 wherein the concentration of sodium hydroxide in the caustic etchant is from about 58% to about 68% by weight.

48. The etching process of claim 47 wherein the concentration of sodium hydroxide in the caustic etchant is from about 58% to about 63% by weight.

49. The etching process of claim 48 wherein the concentration of sodium hydroxide in the caustic etchant is from about 61% to about 63% weight.

50. The etching process of claim 42 wherein the source of hydroxide ions comprises potassium hydroxide.

51. The etching process of claim 50 wherein the concentration of potassium hydroxide in the caustic etchant is at least about 57% by weight.

52. The etching process of claim 51 wherein the concentration of potassium hydroxide in the caustic etchant is at least about 60% by weight.

53. The etching process of claim 51 wherein the concentration of potassium hydroxide in the caustic etchant is no more than about 63% by weight.

54. The etching process of claim 53 wherein the concentration of potassium hydroxide in the caustic etchant is from about 57% to about 63% by weight.

55. The etching process of claim 54 wherein the concentration of potassium hydroxide in the caustic etchant is from about 60% to about 63% by weight.

56. The etching process of claim 33 wherein the concentration of water in the caustic etchant is at least about 20% by weight.

57. The etching process of claim 56 wherein the concentration of water in the caustic etchant is at least about 25% by weight.

58. The etching process of claim 57 wherein the concentration of water in the caustic etchant is from about 30% to about 42% by weight.

59. The etching process of claim 58 wherein the concentration of water in the caustic etchant is from about 30% to about 37% by weight.

60. The etching process of claim 33 wherein the caustic etchant further comprises a salt additive, the salt additive comprising a compound selected from the group consisting of inorganic alkali and alkaline earth metal salts and mixtures thereof.

61. The etching process of claim 60 wherein the concentration of salt additive in the caustic etchant is no more than about 25% by weight.

62. The etching process of claim 61 wherein the concentration of salt additive in the caustic etchant is from about 5% to about 25% by weight.

63. An etching process for removing silicon from the surface of a silicon wafer, the process comprising contacting the surface of the silicon wafer with a caustic etchant in the form of an aqueous solution comprising water and a source of hydroxide ions, the concentration of the source of hydroxide ions in the caustic etchant being at least about 70% of the saturation concentration of the source of hydroxide ions in the caustic etchant.

64. The etching process of claim 63 wherein the concentration of the source of hydroxide ions in the caustic etchant is at least about 74% of the saturation concentration of the source of hydroxide ions in the caustic etchant.

65. The etching process of claim 64 wherein the concentration of the source of hydroxide ions in the caustic etchant is at least about 77% of the saturation concentration of the source of hydroxide ions in the caustic etchant.

66. The etching process of claim 63 wherein the concentration of the source of hydroxide ions in the caustic etchant is less than about 95% of the saturation concentration of the source of hydroxide ions in the caustic etchant.

67. The etching process of claim 66 wherein the concentration of the source of hydroxide ions in the caustic etchant is from about 74% to about 90% of the saturation concentration of the source of hydroxide ions in the caustic etchant.

68. The etching process of claim 67 wherein the concentration of the source of hydroxide ions in the caustic etchant is from about 74% to about 81% of the saturation concentration of the source of hydroxide ions in the caustic etchant.

69. The etching process of claim 63 wherein the source of hydroxide ions comprises an alkali metal hydroxide selected from the group consisting of sodium hydroxide and potassium hydroxide.

70. The etching process of claim 69 wherein the source of hydroxide ions comprises sodium hydroxide.

71. The etching process of claim 69 wherein the source of hydroxide ions comprises potassium hydroxide.

72. The etching process of claim 63 wherein the caustic etchant further comprises a salt additive, the salt additive comprising a compound selected from the group consisting of inorganic alkali and alkaline earth metal salts and mixtures thereof.

73. The etching process of claim 72 wherein the concentration of salt additive in the caustic etchant is no more than about 25% by weight.

74. The etching process of claim 73 wherein the concentration of salt additive in the caustic etchant is from about 5% to about 25% by weight.

75. The etching process of claim 63 wherein the concentration of water in the caustic etchant is at least about 20% by weight.

76. The etching process of claim 75 wherein the concentration of water in the caustic etchant is at least about 25% by weight.

77. The etching process of claim 76 wherein the concentration of water in the caustic etchant is from about 30% to about 42% by weight.

78. The etching process of claim 77 wherein the concentration of water in the caustic etchant is from about 30% to about 37% by weight.

79. The etching process of claim 63 wherein the temperature of the caustic etchant contacted with the silicon wafer is at least about 70°C.

80. The etching process of claim 79 wherein the temperature of the caustic etchant contacted with the silicon wafer is from about 70°C to about 120°C.

81. The etching process of claim 80 wherein the temperature of the caustic etchant contacted with the silicon wafer is from about 75°C to about 85°C.

82. An etching process for removing silicon from the surface of a silicon wafer, the process comprising contacting the surface of the silicon wafer with a caustic etchant in the form of an aqueous solution comprising water, hydroxide ions, and a salt additive that does not decompose or react in the caustic etchant, the salt additive comprising a compound selected from the group consisting of inorganic alkali and alkaline earth metal salts and mixtures thereof, the concentration of the salt additive in the caustic etchant being at least about 4 mole percent.

83. The etching process of claim 82 wherein the concentration of the salt additive in the caustic etchant is at least about 5 mole percent.

84. The etching process of claim 82 wherein the concentration of the salt additive in the caustic etchant is at least about 10 mole percent.

85. The etching process of claim 82 wherein the concentration of the salt additive in the caustic etchant is from about 4 to about 15 mole percent.

86. The etching process of claim 82 wherein the salt additive comprises an inorganic sodium or potassium salt.

87. The etching process of claim 82 wherein the salt additive comprises an inorganic salt selected from the group consisting of potassium carbonate, potassium phosphate, potassium fluoride, potassium iodide, potassium chloride, potassium pyrophosphate, potassium subphosphate, potassium hypophosphate, potassium orthophosphite, potassium nitrate, potassium nitrite, potassium peroxy carbonate, potassium chlorate, potassium acetate, potassium citrate, potassium borate, potassium fluoroborate, potassium sulfate, potassium propionate, potassium selenate, potassium stannate, potassium tartrate, potassium thioantimonate, potassium thiocyanate, potassium thiosulfate, potassium tungstate, sodium carbonate, sodium phosphate, sodium fluoride, sodium iodide, sodium chloride, sodium pyrophosphate, sodium subphosphate, sodium hypophosphate, sodium orthophosphite, sodium nitrate, sodium nitrite, sodium peroxy carbonate, sodium chlorate, sodium acetate, sodium citrate, sodium borate, sodium fluoroborate, sodium sulfate, sodium sulfide, sodium propionate, sodium selenate, sodium stannate, sodium tartrate, sodium thioantimonate, sodium thiocyanate, sodium thiosulfate, sodium tungstate, and mixtures thereof.

88. The etching process of claim 87 wherein the salt additive comprises potassium fluoride.

89. The etching process of claim 87 wherein the salt additive comprises potassium carbonate.

90. The etching process of claim 82 wherein the salt additive comprises an inorganic alkali metal or alkaline earth metal salt hydrate.

91. The etching process of claim 82 wherein the concentration of hydroxide ions in the caustic etchant is no more than about 20 mole percent.

92. The etching process of claim 82 wherein the concentration of hydroxide ions in the caustic etchant is no more than about 15 mole percent.

93. The etching process of claim 82 wherein the concentration of hydroxide ions is from about 10 to about 15 mole percent.

94. The etching process of claim 82 wherein the concentration of water in the caustic etchant is no more than about 85 mole percent.

95. The etching process of claim 82 wherein the concentration of water in the caustic etchant is from about 70 to about 85 mole percent.

96. The etching process of claim 82 wherein the concentration of water in the caustic etchant is from about 75 to about 85 mole percent.

97. The etching process of claim 82 wherein the pH of the caustic etchant is at least about 13.

98. The etching process of claim 82 wherein the pH of the caustic etchant is from about 13.9 to about 14.

99. An etching process for removing silicon from the surface of a silicon wafer, the process comprising contacting the surface of the silicon wafer with a caustic etchant in the form of an aqueous solution comprising water, hydroxide ions, and a salt additive that does not decompose or react in the caustic etchant, the salt additive comprising a compound selected from the group consisting of potassium carbonate and potassium fluoride, the concentration of the salt additive in the caustic etchant being at least about 1 mole percent.

100. A caustic etchant for etching a silicon wafer, the caustic etchant in the form of an aqueous solution comprising water, hydroxide ions, and a salt additive that does not decompose or react in the caustic etchant, the salt additive comprising a compound selected from the group consisting of inorganic alkali and alkaline earth metal salts and mixtures thereof, the concentration of salt additive in the caustic etchant being at least about 4 mole percent.

101. The caustic etchant of claim 100 wherein the concentration of the salt additive in the caustic etchant is at least about 5 mole percent.

102. The caustic etchant of claim 100 wherein the concentration of the salt additive in the caustic etchant is at least about 10 more percent.

103. The caustic etchant of claim 100 wherein the concentration of the salt additive in the caustic etchant is from about 4 to about 15 mole percent.

104. The caustic etchant of claim 100 wherein the salt additive comprises an inorganic sodium or potassium salt.

105. The caustic etchant of claim 100 wherein the salt additive comprises an inorganic salt selected from the group consisting of potassium carbonate, potassium phosphate, potassium fluoride, potassium iodide, potassium chloride, potassium pyrophosphate, potassium subphosphate, potassium hypophosphate, potassium orthophosphite, potassium nitrate, potassium nitrite, potassium peroxy carbonate, potassium chlorate, potassium acetate, potassium citrate, potassium borate, potassium fluoroborate, potassium sulfate, potassium propionate, potassium selenate, potassium stannate, potassium tartrate, potassium thioantimonate, potassium thiocyanate, potassium thiosulfate, potassium tungstate, sodium carbonate, sodium phosphate, sodium fluoride, sodium iodide, sodium chloride, sodium pyrophosphate, sodium subphosphate, sodium hypophosphate, sodium orthophosphite, sodium nitrate, sodium nitrite, sodium peroxy carbonate, sodium chlorate, sodium acetate, sodium citrate, sodium borate, sodium fluoroborate, sodium sulfate, sodium sulfide, sodium propionate, sodium selenate, sodium stannate, sodium tartrate, sodium thioantimonate, sodium thiocyanate, sodium thiosulfate, sodium tungstate and mixtures thereof.

106. The caustic etchant of claim 105 wherein the salt additive is potassium fluoride.

107. The caustic etchant of claim 105 wherein the salt additive is potassium carbonate.

108. The caustic etchant of claim 100 wherein the salt additive comprises an inorganic alkali metal or alkaline earth metal salt hydrate.

109. The caustic etchant of claim 100 wherein the hydroxide ions are anions of a compound selected from the group consisting of potassium hydroxide, sodium hydroxide, tetramethyl ammonium hydroxide, cesium hydroxide, lithium hydroxide, and mixtures thereof.

110. The caustic etchant of claim 100 wherein the concentration of hydroxide ions in the caustic etchant is no more than about 20 mole percent.

111. The caustic etchant of claim 100 wherein the concentration of hydroxide ions in the caustic etchant is no more than about 15 mole percent.

112. The caustic etchant of claim 100 wherein the concentration of hydroxide ions is from about 10 to about 15 mole percent.

113. The caustic etchant of claim 100 wherein the concentration of water in the caustic etchant is no more than about 85 mole percent.

114. The caustic etchant of claim 100 wherein the concentration of water in the caustic etchant is from about 70 to about 85 mole percent.

115. The caustic etchant of claim 100 wherein the concentration of water in the caustic etchant is from about 75 to about 85 mole percent.

116. The caustic etchant of claim 100 wherein the pH of the caustic etchant is at least about 13.

117. The caustic etchant of claim 100 wherein the pH of the caustic etchant is from about 13.9 to about 14.

118. A caustic etchant for etching a silicon wafer, the caustic etchant in the form of an aqueous solution comprising water, hydroxide ions, and a salt additive that does not decompose or react in the caustic etchant, the salt additive comprising a compound selected from the group consisting of potassium carbonate and potassium fluoride, the concentration of salt additive in the caustic etchant being at least about 1 mole percent.

119. A single crystal silicon wafer comprising a central axis, a front surface and a back surface which are generally perpendicular to the central axis, a peripheral edge, and a radius, R , extending from the central axis to the peripheral edge of the wafer, wherein after polishing the single crystal silicon wafer exhibits:

- a front surface site flatness average of less than about $0.13\ \mu\text{m}$,
- a front surface site flatness maximum of less than about $0.18\ \mu\text{m}$,
- a front surface $2\ \text{mm} \times 2\ \text{mm}$ nanotopography of less than about $20\ \text{nm}$, and
- a front surface $10\ \text{mm} \times 10\ \text{mm}$ nanotopography of less than about $40\ \text{nm}$.

120. The single crystal silicon wafer of claim 119 wherein the wafer exhibits a front surface site flatness average of from about $0.05\ \mu\text{m}$ to about $0.13\ \mu\text{m}$.

121. The single crystal silicon wafer of claim 120 wherein the wafer exhibits a front surface site flatness average of from about $0.05\ \mu\text{m}$ to about $0.8\ \mu\text{m}$.

122. The single crystal silicon wafer of claim 119 wherein the wafer exhibits a front surface site flatness maximum of from about $0.10\ \mu\text{m}$ to about $0.18\ \mu\text{m}$.

123. The single crystal silicon wafer of claim 122 wherein the wafer exhibits a front surface site flatness maximum of from about 0.10 μm to about 0.15 μm .

124. The single crystal silicon wafer of claim 119 wherein in an annular region of the wafer from 2/3R measured from the central axis of the wafer to the peripheral edge of the wafer, the wafer exhibits a front surface site flatness average of from about 0.05 μm to about 0.13 μm .

125. The single crystal silicon wafer of claim 119 wherein in an annular region of the wafer from 2/3R measured from the central axis of the wafer to the peripheral edge of the wafer, the wafer exhibits a front surface site flatness maximum of from about 0.05 μm to about 0.18 μm .

126. The single crystal silicon wafer of claim 119 wherein the wafer exhibits a front surface 2 mm x 2 mm nanotopography of from about 10 nm to about 20 nm.

127. The single crystal silicon wafer of claim 119 wherein the wafer exhibits a front surface 10 mm x 10 mm nanotopography of from about 25 nm to about 40 nm.

128. The single crystal silicon wafer of claim 119 wherein the wafer exhibits a back surface reflectance of less than about 100 gloss units.

129. The single crystal silicon wafer of claim 119 wherein the wafer exhibits an average back surface roughness of from about 0.15 μm Ra to about 0.25 μm Ra.